MasterClass: Artificial Intelligence for Automotive

October 20 and 21, 2025

Driving the Future: An Overview of AI for the Automotive Sector

GSA
UTFPR
UNIVERSIDADE TECNOLÓGICA FEDERAL DO PARANÁ
CAMPUS PONTA GROSSA

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MATLAB & SIMULINK

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Responsabilities

Associate Professor
Teaching

Chair
Management

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OPENCADD

GSA

GSA
Since 2014

GRUPO DE SISTEMAS AUTOMOTIVOS

HW/SW

Basic Resources

- 4 Database Servers
- 16 IBM-PC
- 14 External Hard Drives
- 6 Laptops
- 1 MicroAutobox I
- Vector Tools – SW and HW
- AVL tools for ADAS and vehice dynamics
- Dyna4 for ADAS and vehicle dynamics
- DieselDiag – Chiptronic
- dSPACE – ControlDesk, ASM, VEOS, SystemDesk e TargetLink
- MathWorks – MATLAB, Simulink e Toolbox – Full features avaiable to design, build and test algrithms and advanced control strategies
- Vector – CANalyzer, CANOe, etc
- Gliwa tools
- 12 Digital cameras – Logitech and Axis
- Oscilloscope and advanced Scope with CAN Bus
- Multimeter
- SW for OSEK and AUTOSAR
- ...

Vehicles

Renault CAPTUR

Jeep Renegade

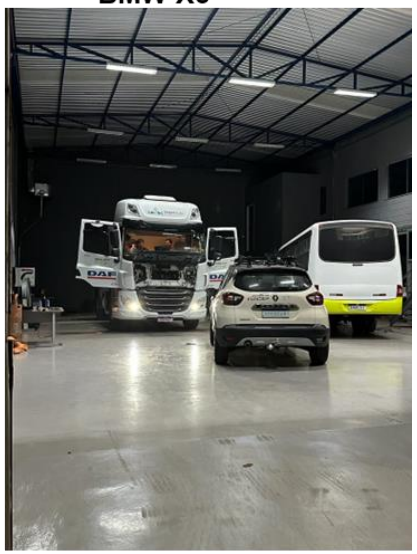
DAF Trucks

BMW X5

Infrastrure

The home of research, development, and innovation
Automotive System

Testing



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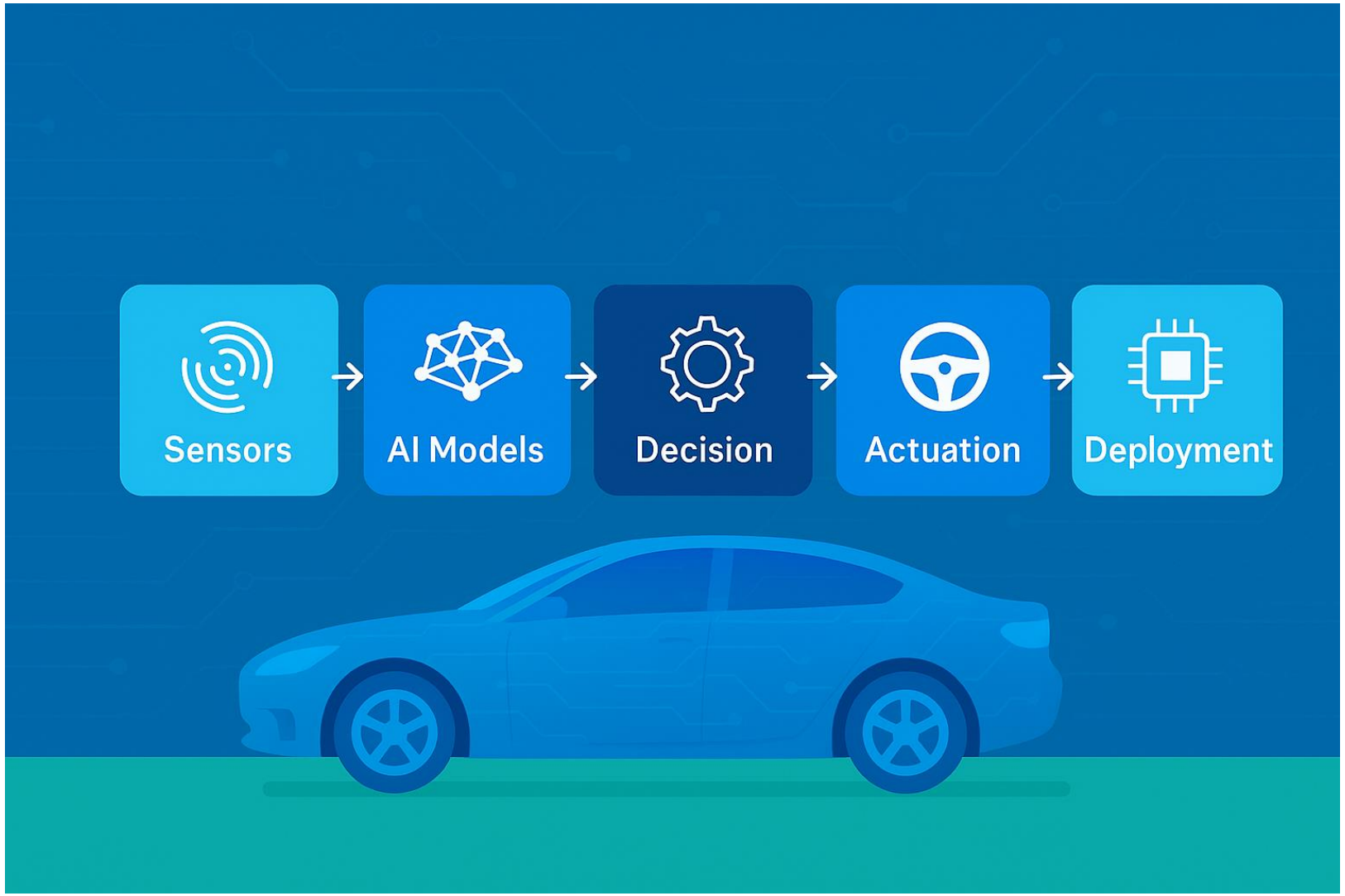
1. Introduction



1. Introduction

- The automotive industry is undergoing a **fundamental transformation** driven by Artificial Intelligence (AI), enabling vehicles to perceive, decide, and act autonomously.
- Integration of AI spans across **Connected, Autonomous, Shared, and Electric (CASE)** domains.
- AI algorithms power **advanced perception, decision-making, predictive maintenance, and driver assistance systems (ADAS)**.
- MATLAB® and Simulink® provide a **comprehensive ecosystem** for the design, simulation, and validation of intelligent automotive systems—from **concept to real-time deployment**.

2. Motivation

2. Motivation

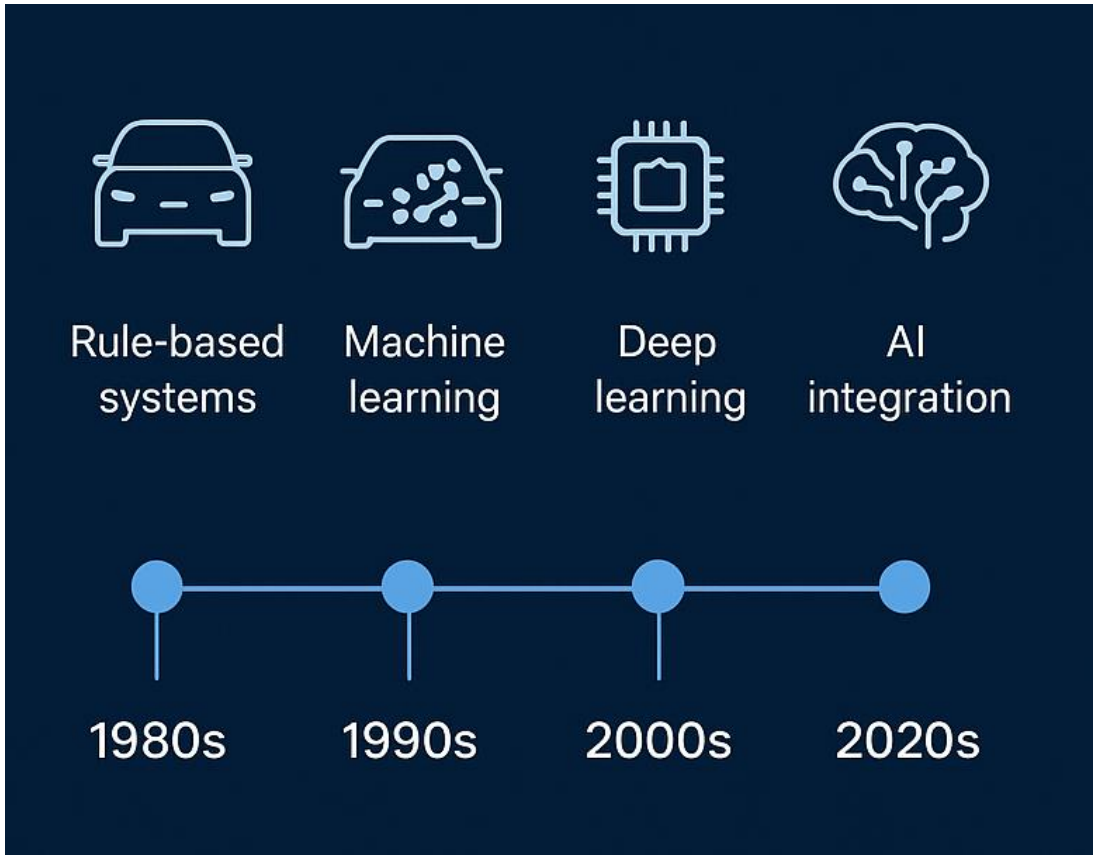
- **Growing Complexity**: Modern vehicles integrate thousands of signals from cameras, radar, lidar, and ECUs — exceeding what traditional rule-based systems can manage.
- **Safety & Efficiency**: AI enables real-time analysis for collision avoidance, adaptive driving, and predictive maintenance.
- **Data Explosion**: Autonomous vehicles generate terabytes of data per day, fueling the need for scalable AI models.
- **Industry Demand**: OEMs and suppliers are rapidly adopting AI-driven development to meet ISO 26262 and SOTIF safety standards.
- **MATLAB® Advantage**: Offers end-to-end support for AI workflows — from data preprocessing to training, simulation, and C-code generation for embedded deployment.

3. AI and the Automotive Revolution

Rapid integration of AI in Connected, Autonomous, Shared, and Electric (CASE) vehicles

Transition from rule-based control to data-driven intelligent systems

Role of MATLAB® & Simulink as a bridge from research to deployment



4. MathWorks Ecosystem for Automotive AI

- MATLAB® Toolboxes:
  - Deep Learning Toolbox™
  - Automated Driving Toolbox™
  - Reinforcement Learning Toolbox™
  - Predictive Maintenance Toolbox™
  - Computer Vision Toolbox™
- Simulink® for system simulation, HIL, code generation (Embedded Coder)
- Visual: MATLAB–Simulink workflow diagram

5. Application Examples

5.1. GSA Achievements

5.2. AI for ADAS and AD

5.3. AI for Automotive

5.4. AI for Perception

5.5. AI for Decision and Control

5.6. Predictive and Diagnostic AI

5.7. AI in Manufacturing and Validation

5.1. GSA Achievements

ENGINE CALIBRATION PROCESS OPTIMIZATION USING ARTIFICIAL INTELLIGENCE

SOFTWARE DEVELOPMENT FOR BUILDING ENGINE BLACK-BOX MODELS FOR SIMULATIONS.

Objective: Save time, resources and reduce repeat of experiments.

2022

Hilkija Gaius, E.E.

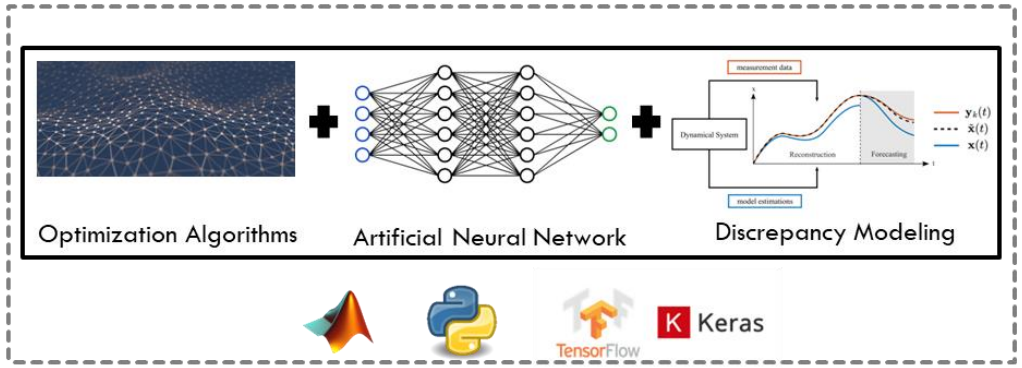
M.Sc. Student

Electrical Engineering

UTFPR GSA

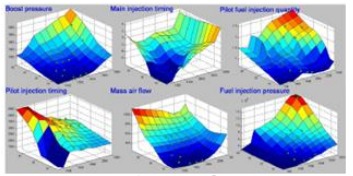
Software Application

- Engine data aquisition
- Reduced data sheet



- Engine Black-Box Model
- Virtual data sheet

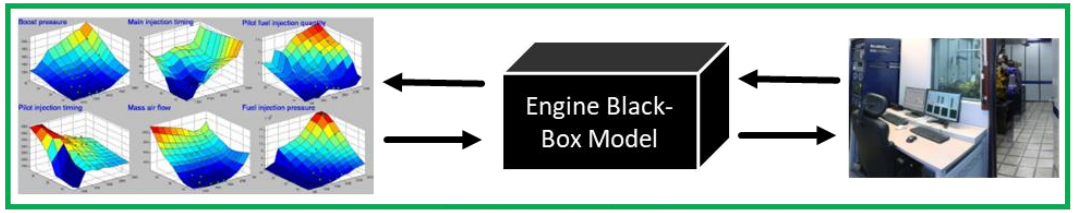
Calibration base on Engine Model



Innovation is here

GSA

Bench Testing



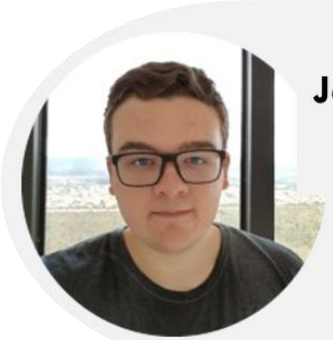
Fast and robust

Time, Resources, and Repeat of experiments

5.1. GSA Achievements

REAL-TIME ADAPTIVE OBJECT DETECTION AND TRACKING FOR AUTONOMOUS VEHICLES

Objective: Development of versatile multistage algorithm for multiple object classification and localization for real-time environments:



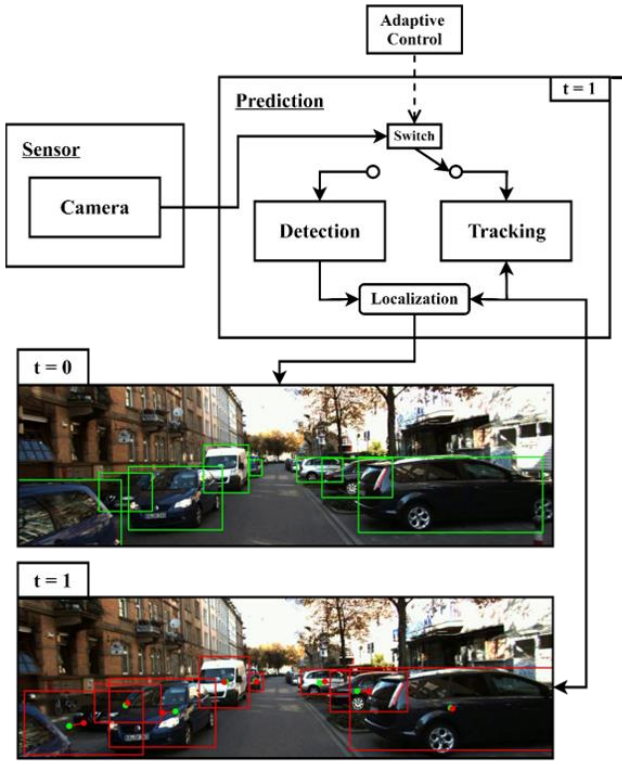
2022

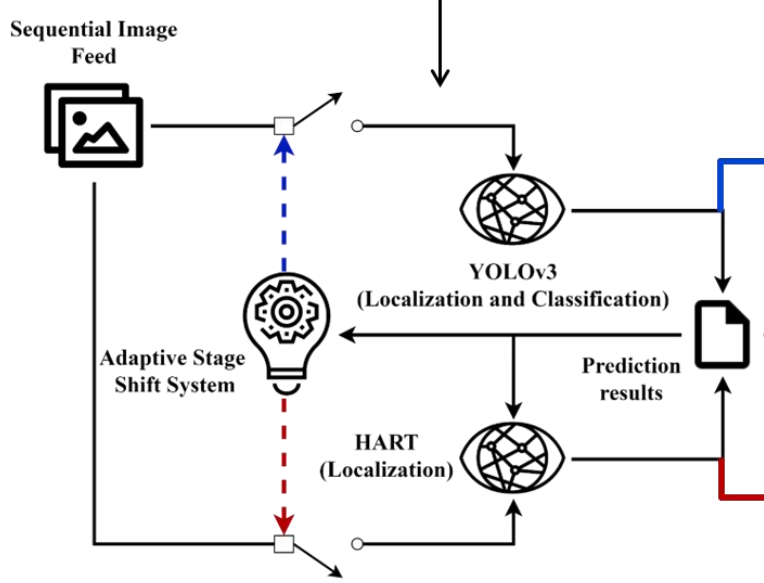
João E. Hoffmann, M.Sc.

Researcher

Electrical Engineering

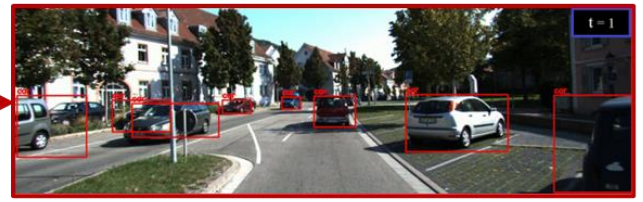
UTFPR GSA





Post-Prediction Processes

- New classification;
- Accurate localization.



- Fast localization based on prior information.

5.1. GSA Achievements

DESIGN AND DEVELOPMENT OF A MODEL-BASED PREDICTIVE CONTROL SYSTEM FOR AUTOMOTIVE THERMAL MANAGEMENT

2022

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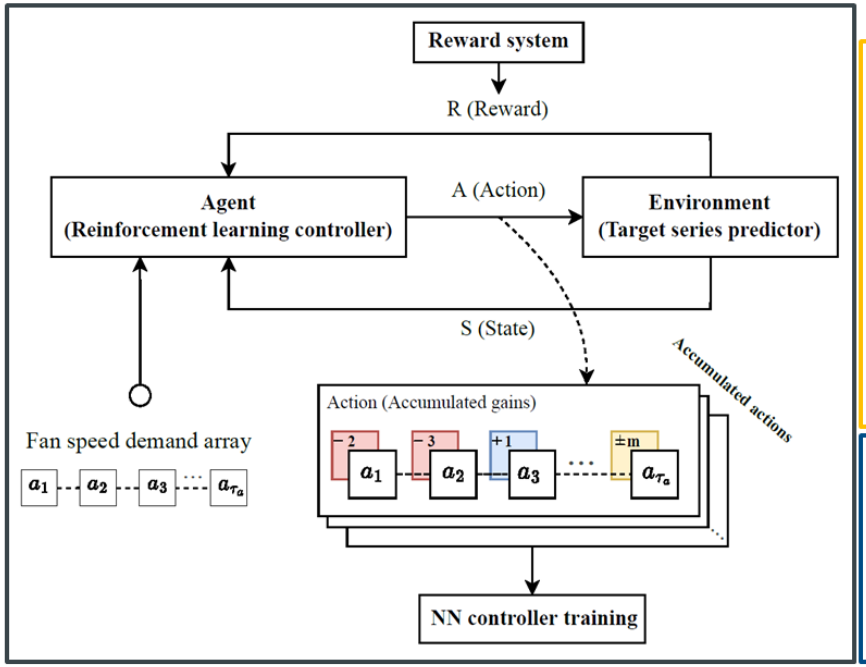
Researcher

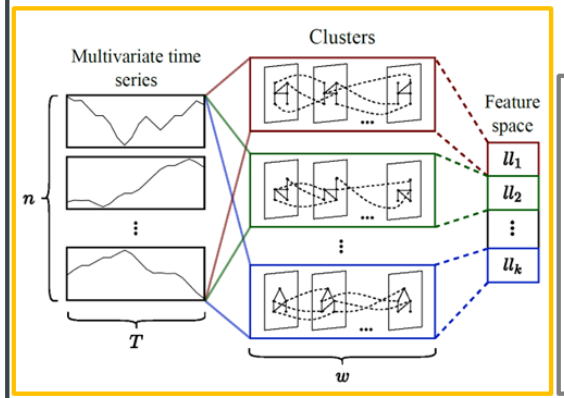
Electrical Engineering

Objective: Development of a model-based predictive control (MPC) system with machine learning technologies for the thermal regulation of the refrigerant fluid:

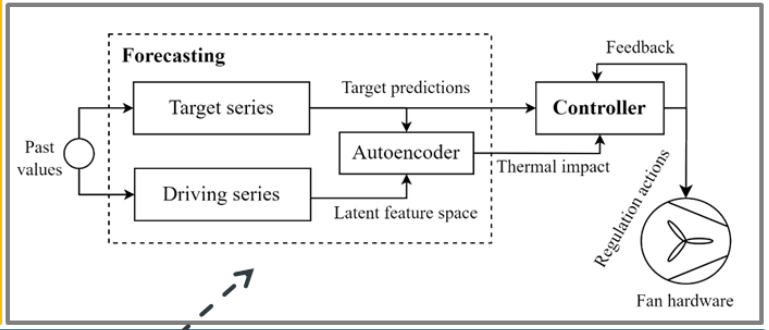
- Offline fan speed optimization with reinforcement learning.

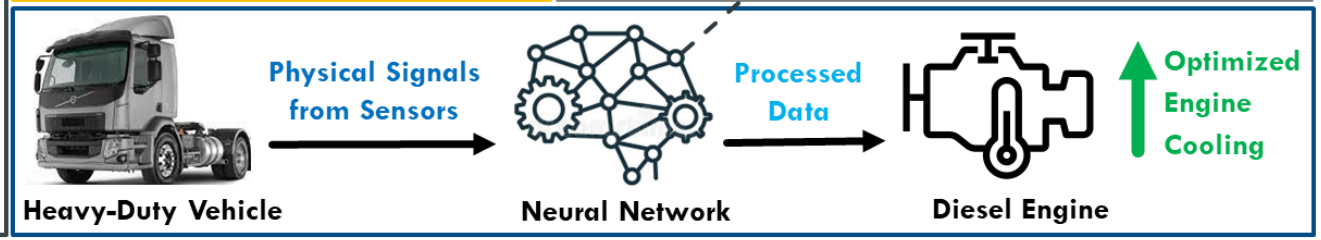


- Dimensionality reduction of processed thermal impacts.



- Neural network controller for the in-vehicle forecasting and regulation





5.1. GSA Achievements

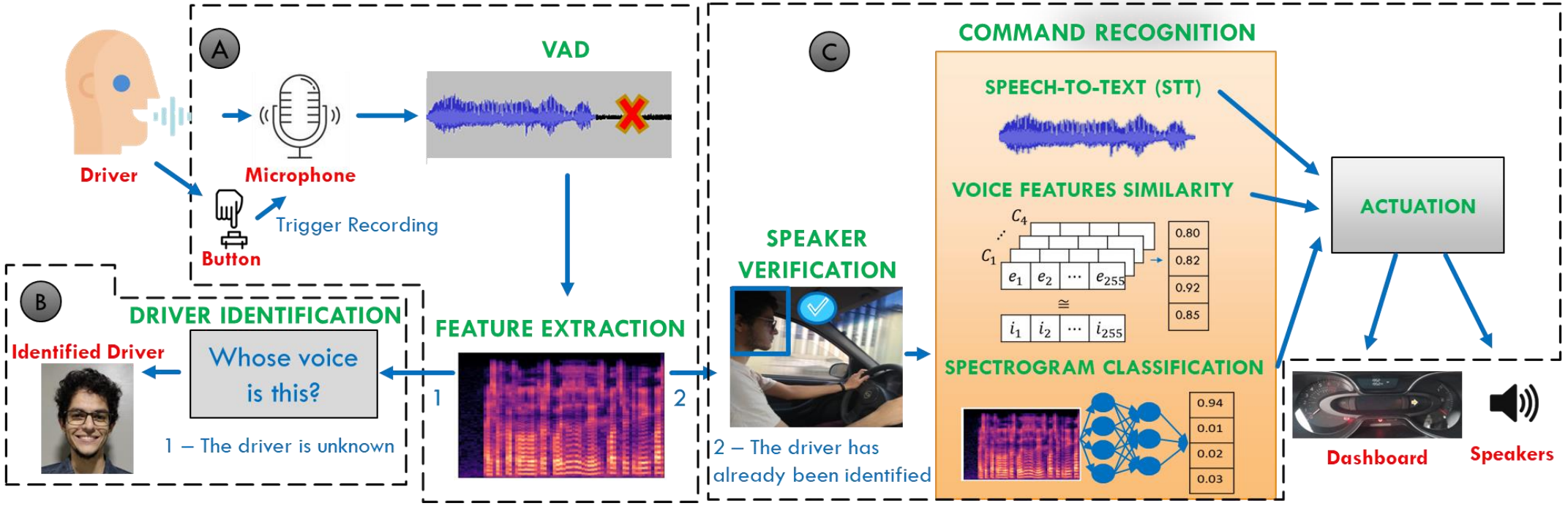
DESIGN AND DEVELOPMENT OF A VOICE ASSISTANT FOR AUTOMOTIVE DASHBOARD CONTROL

2022

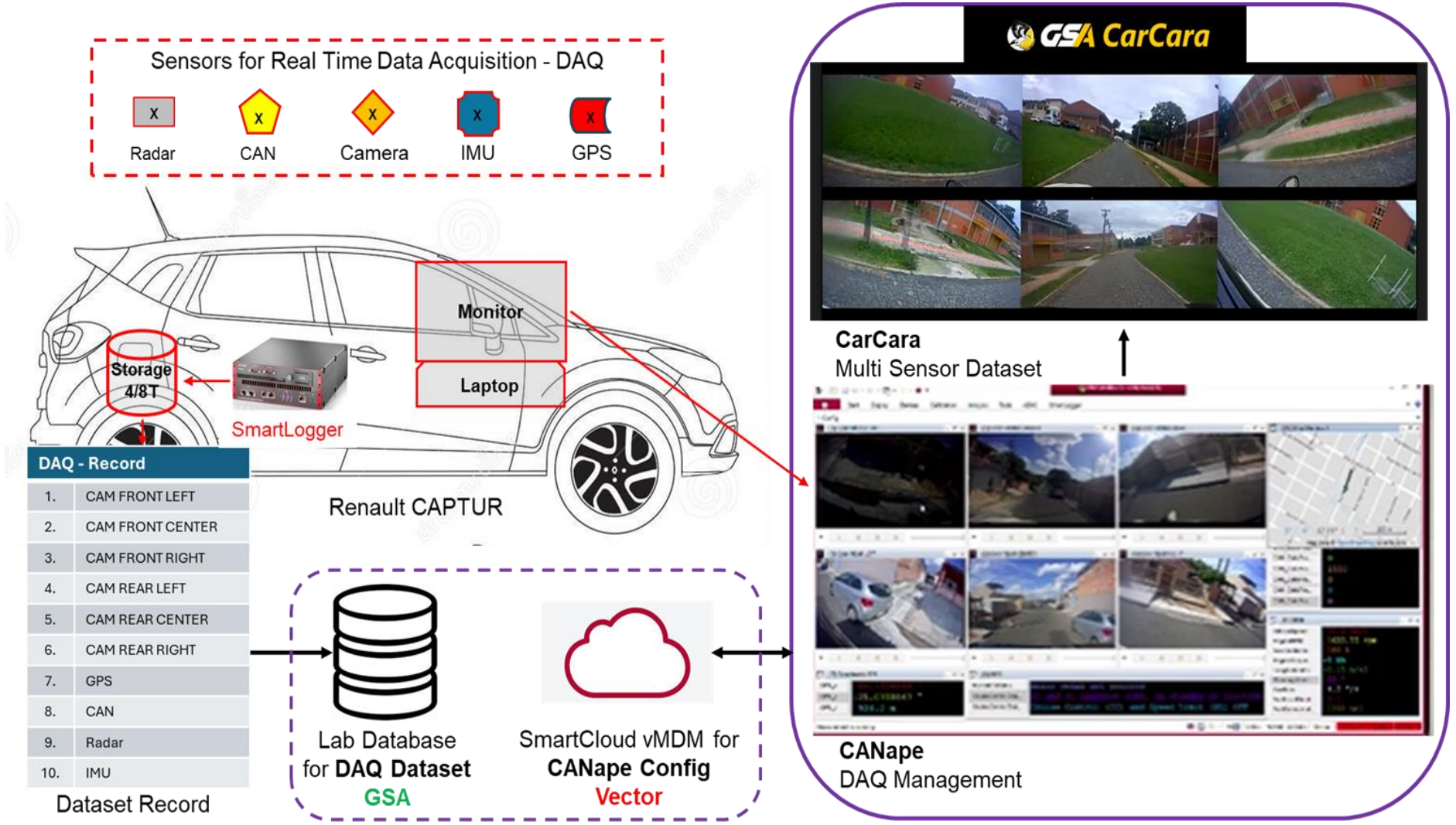
Mathias Luz, M.Sc.
Researcher
Electrical Engineering

THE PROJECT AIMS TO DEVELOP AN ADVANCED COMMAND CONTROL SYSTEM BASED ON VOICE RECOGNITION WITH ARTIFICIAL INTELLIGENCE TECHNOLOGIES.

Objective: Development of a system capable of activating vehicle functions by voice commands. These functions include but are not limited to headlights and turn signals control.



5.1. GSA Achievements



5.2. AI for ADAS and AD

ADAS Parking Assistance

ADAS Driving Assistance

NVIDIA

- ADAS Control
- Vehicle Dynamic Model
- Steering and Pedal Control

Renesas

- ADAS Control
- Vehicle Dynamic Model
- Steering and Pedal Control

EyeQ4
Mobileye

- Vision processing
- Detection, recognition and tracking

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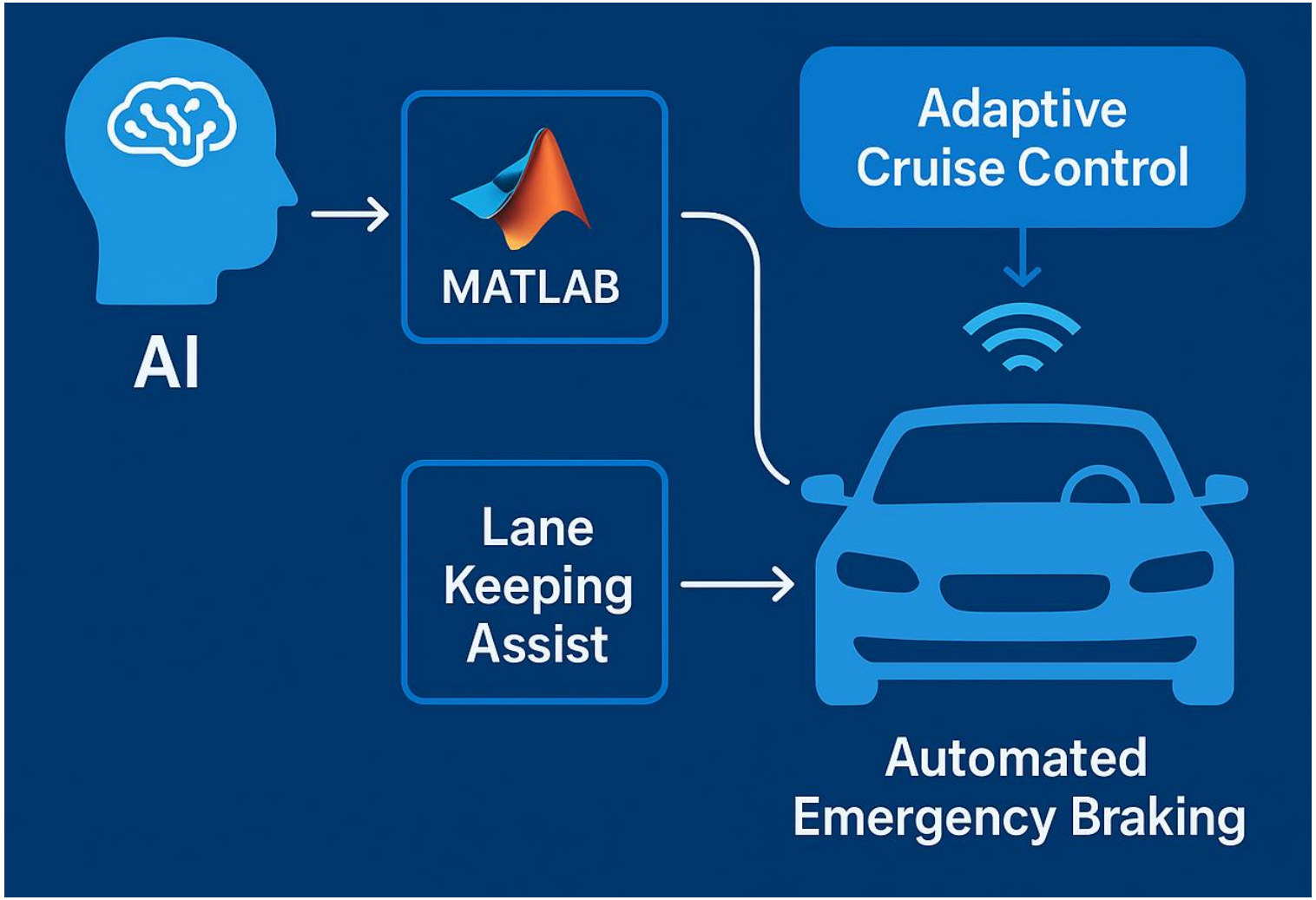
5.2. AI for ADAS and AD



5.2. AI for ADAS and AD

LLM

ITS

Planning

Counterfactuals

Road-rules

Slowing down to prevent risk near a group of pedestrians on the sidewalk

Perception

Attention

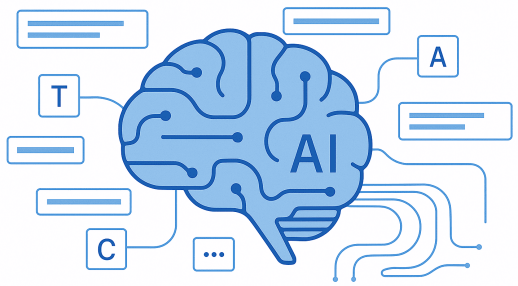
Explains next actions

Infers causes and goals

Understands the scene

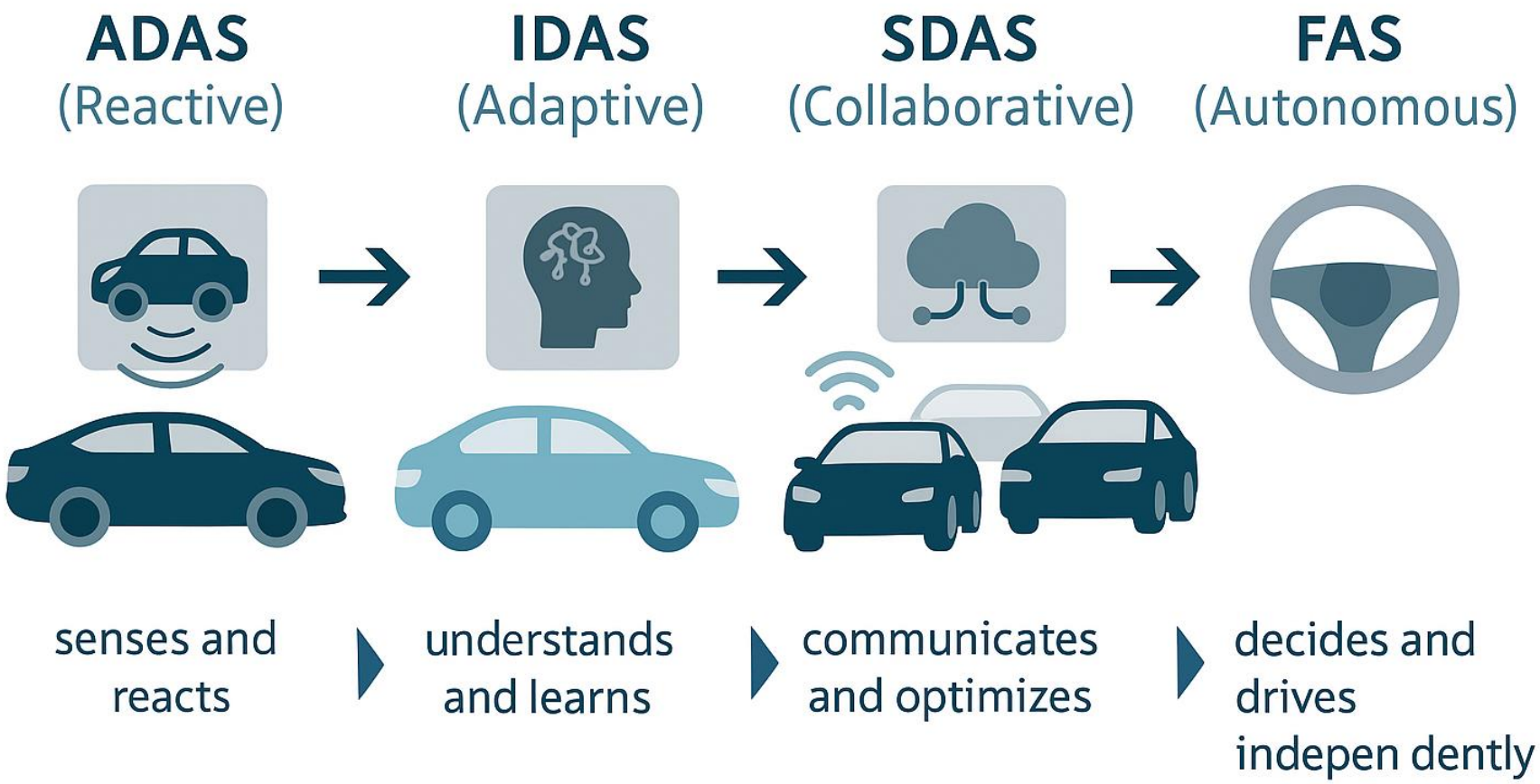
Anticipate risks in an urban leisure area with pedestrians

LARGE LANGUAGE MODEL

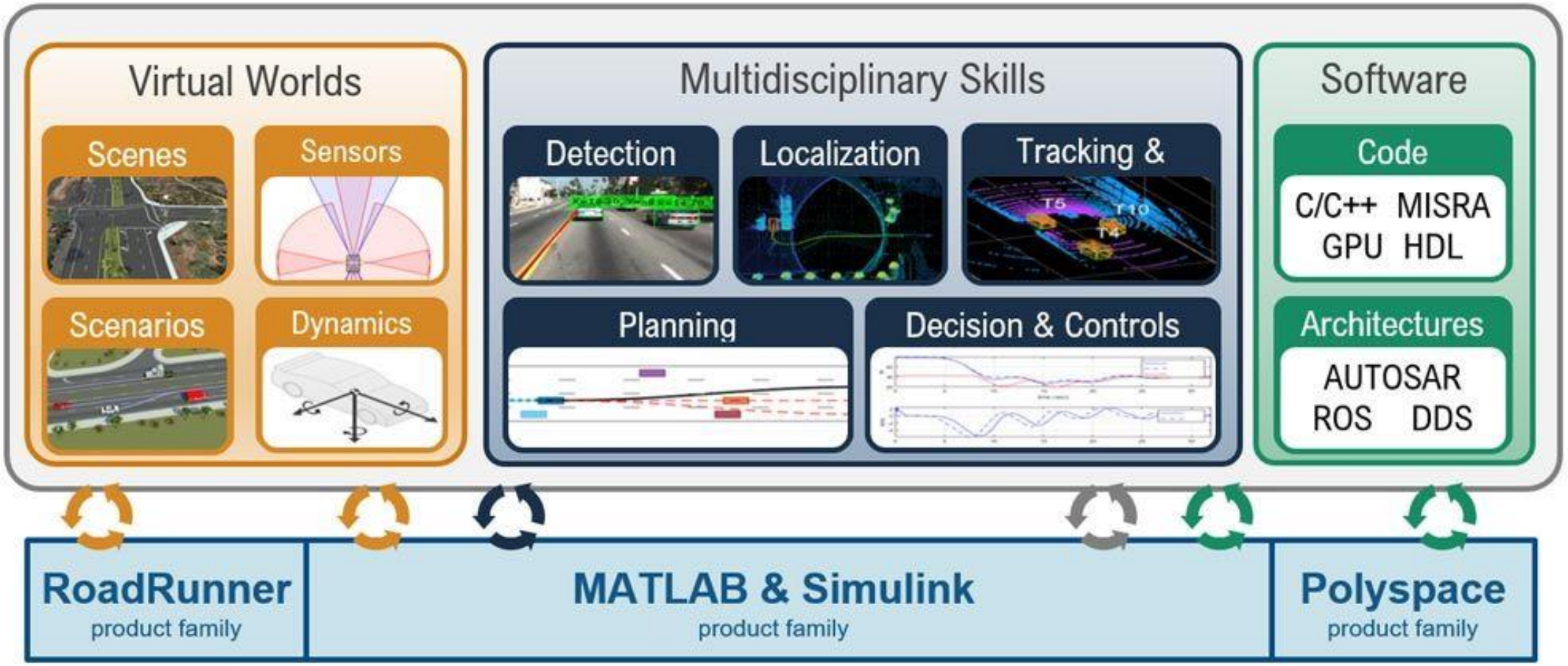


Intersection of LLM and ITS

5.2. AI for ADAS and AD



5.2. AI for ADAS and AD



5.3. AI-Based Automotive

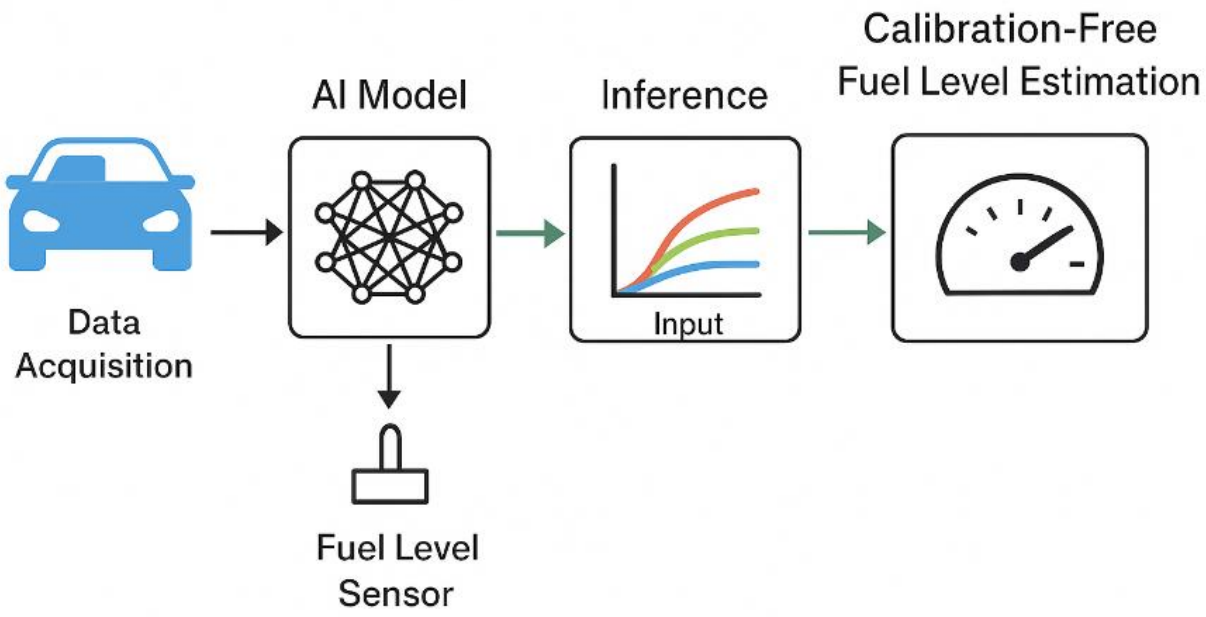
AI-Based Fuel Level Estimation and Sensor Calibration

Problem Statement:

- Accurate fuel level estimation is difficult due to sensor noise, nonlinear behavior, and environmental variations.

Our Solution:

- Using MATLAB® AI models, a Wide Neural Network achieved 96.5% accuracy, ensuring reliable and intelligent fuel prediction.



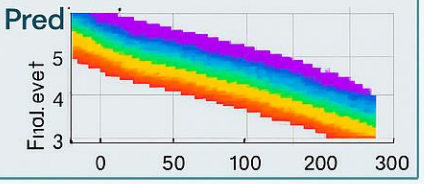
Source: Rafael Dominguez – Luxoft

5.3. AI-Based Automotive

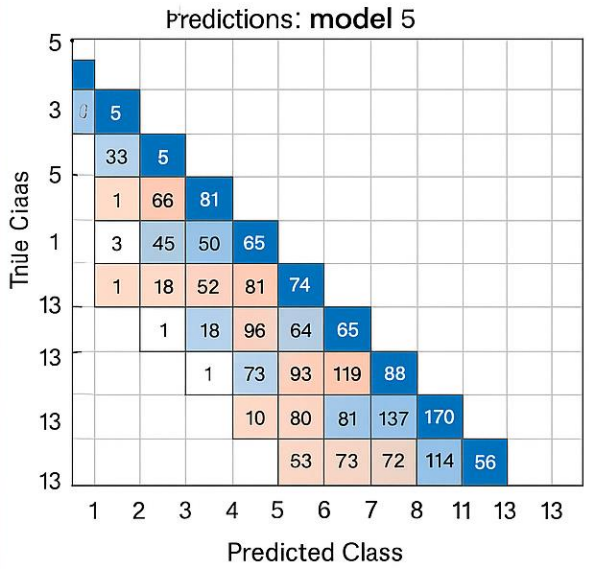
Classification Learning

Evaluation Pane

Models	
Accuracy %)	Accuracy%)
Wide Neural Network	96.4%
Gaussian SVM	96.4%
Fine KNN	96.3%
Medium Neural Network	74.3%
Tree	74.3%



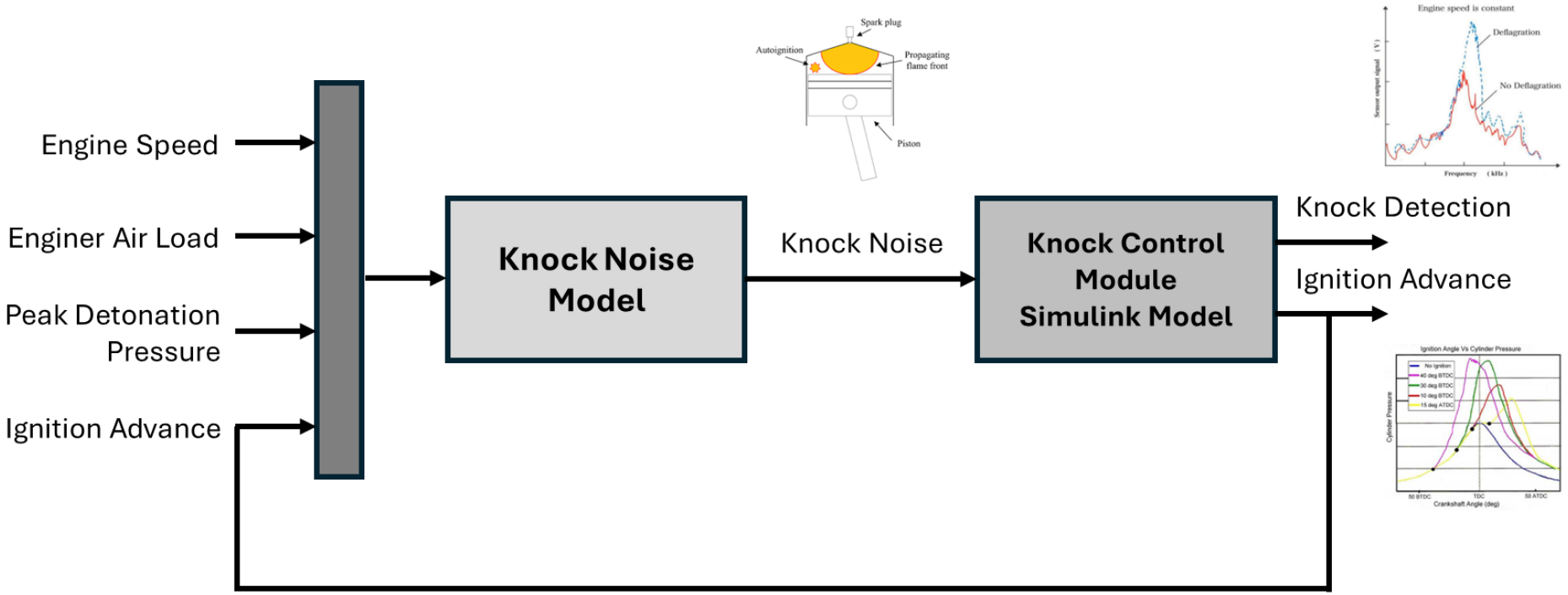
Validation Confusion Matrix



Source: Rafael Dominguez – Luxoft

5.3. AI-Based Automotive

Intelligent Knock Detection and Adaptive Control in Spark Ignition Engine through Time-Series Deep Learning



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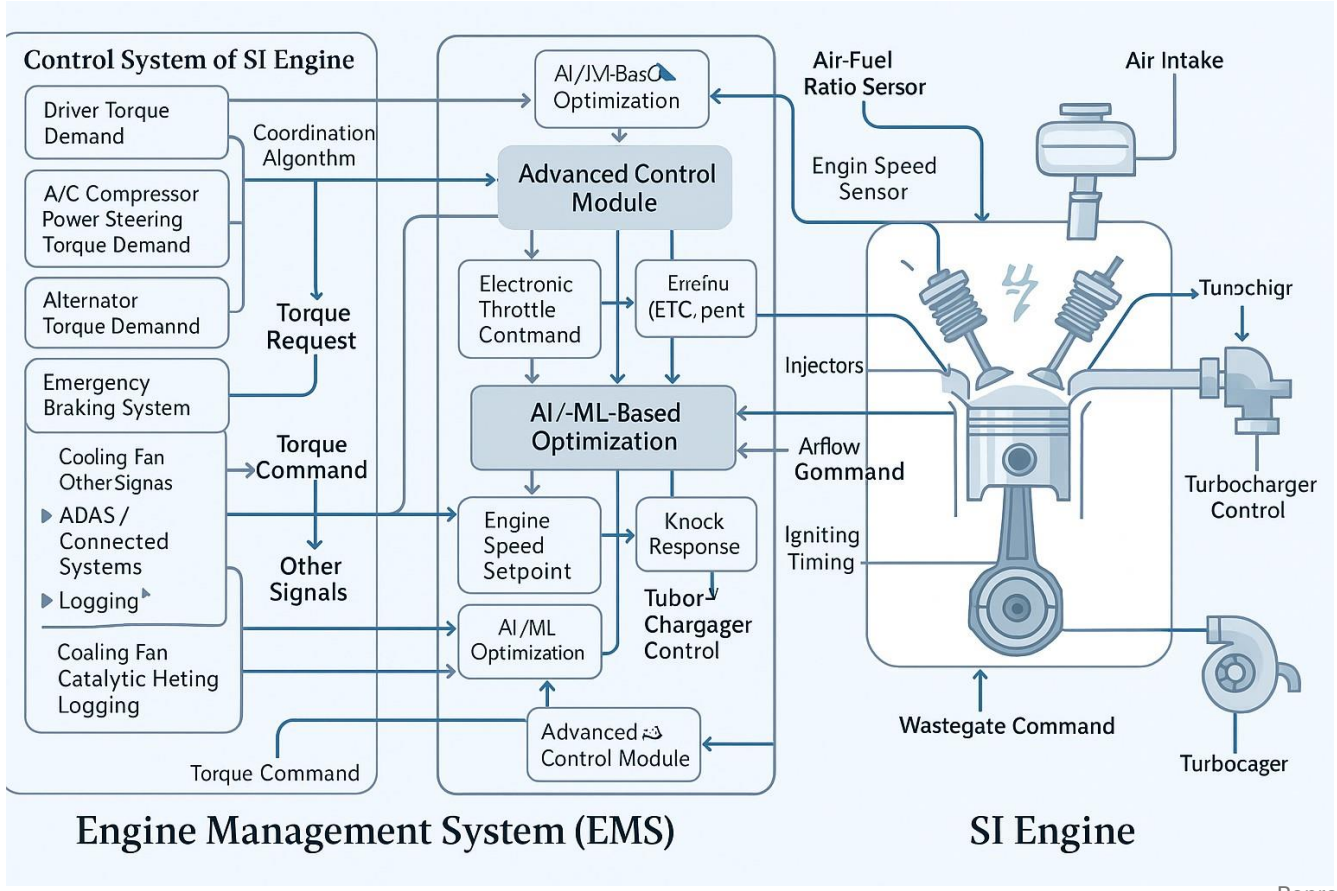
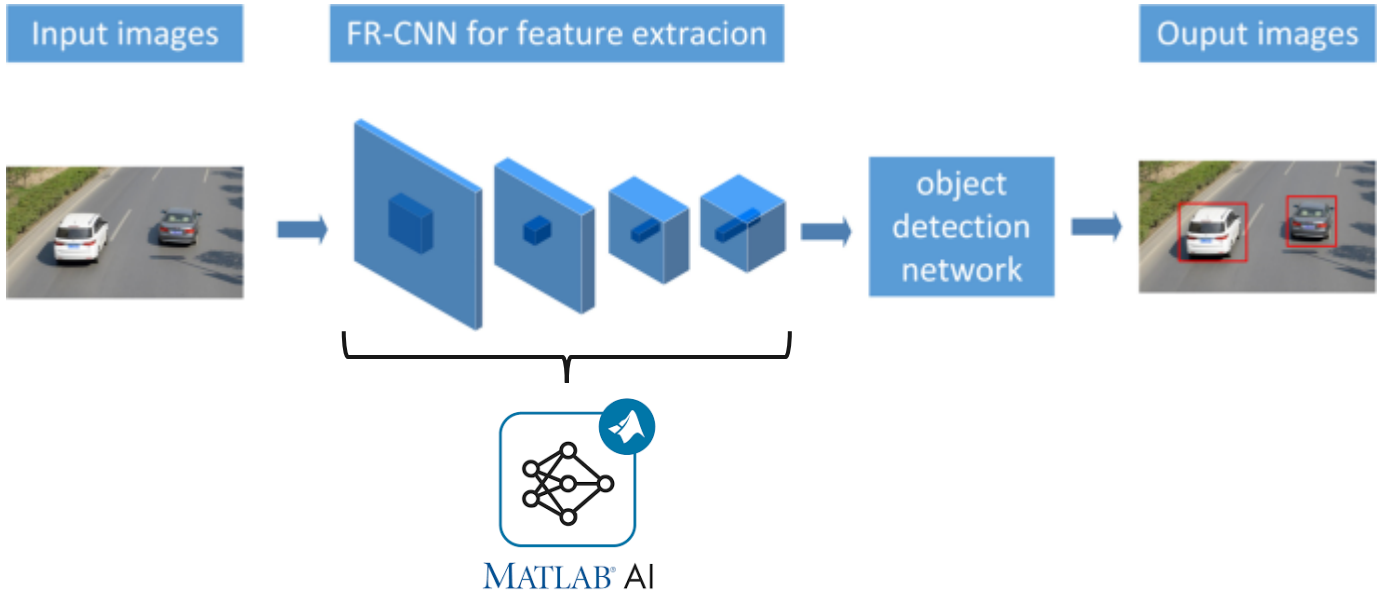
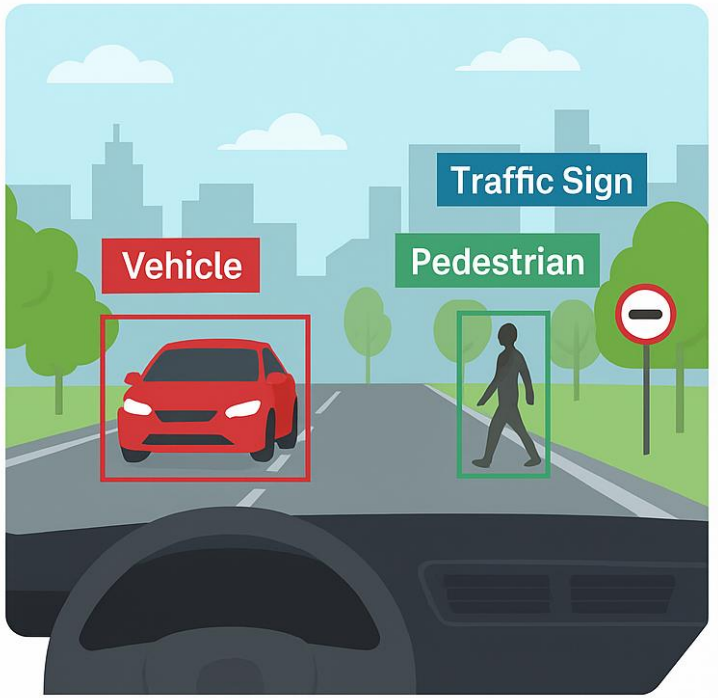


5.4. AI for Perception

Object Detection with Deep Learning (YOLO/CNN)

- Tool: Deep Learning Toolbox™ + Automated Driving Toolbox™
- Application: Detect vehicles, pedestrians, and traffic signs

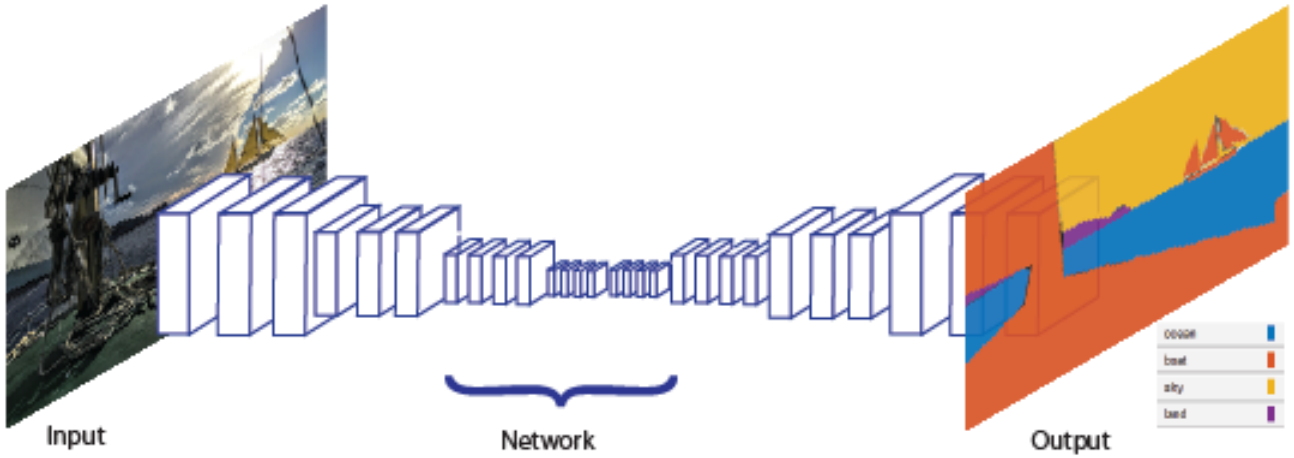




5.4. AI for Perception

Lane Detection Using Semantic Segmentation

- Tool: Deep Learning Toolbox™
- Dataset: Ground truth images and videos
- Result: Lane markings extraction under various conditions



5.4. AI for Perception

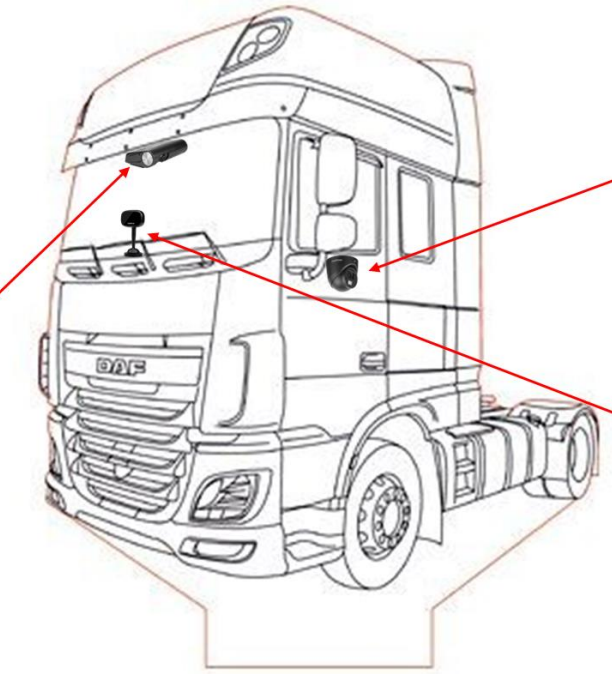
Driver Monitoring System

- Tool: Computer Vision Toolbox™ + Deep Learning Toolbox™
- Use: Detect drowsiness, distraction, and gaze direction

Interbras Devices

1 DCM5004 GW IA

Internal pose (external view) with AI to lane departure warning



2 Cameras VHDM 3020D

External pose below the mirrors on the back view of the left and right sides of the vehicle

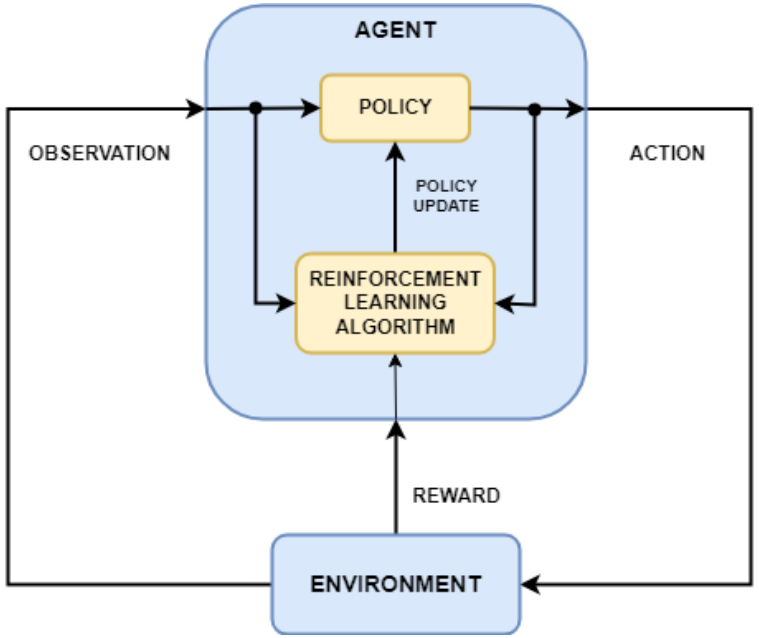
1 VHDM 1012DSM

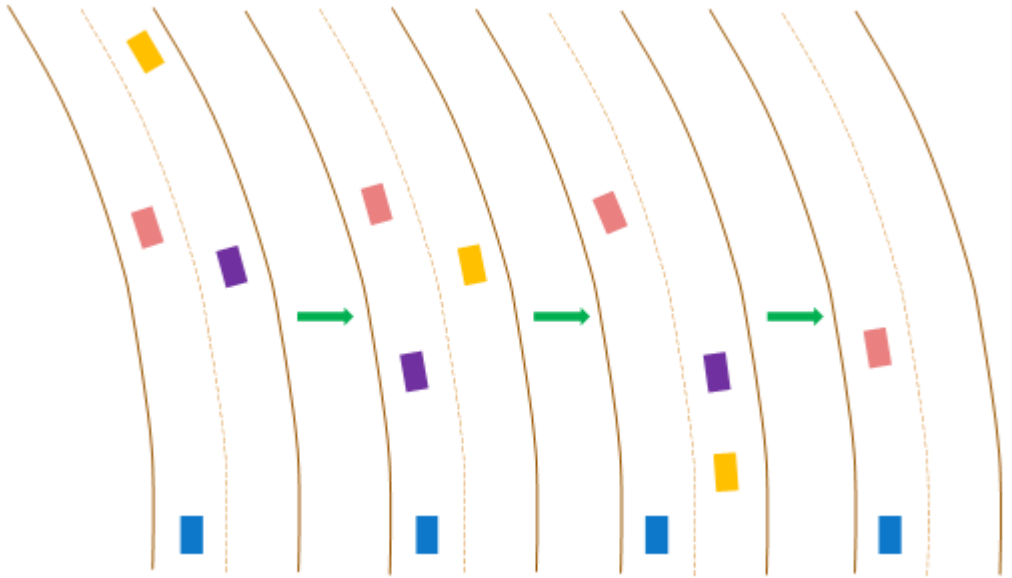
Internal pose (internal view to driver) to monitor when the driver is smoking or using a phone

5.5. AI for Decision and Control

Adaptive Cruise Control (ACC) with Reinforcement Learning

- Tool: Reinforcement Learning Toolbox™ + Simulink®
- Use: Optimize following distance and comfort

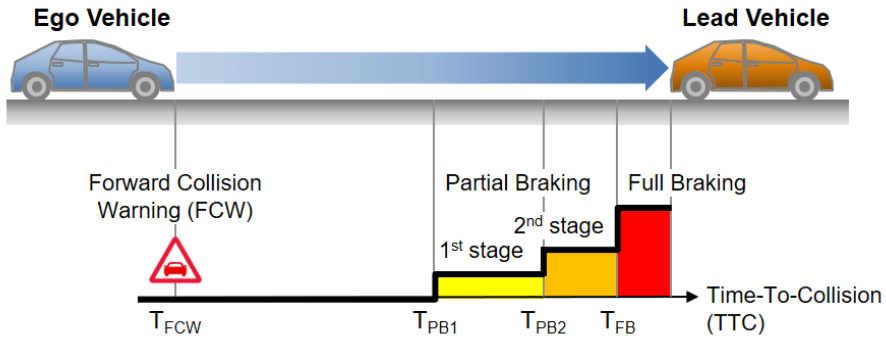


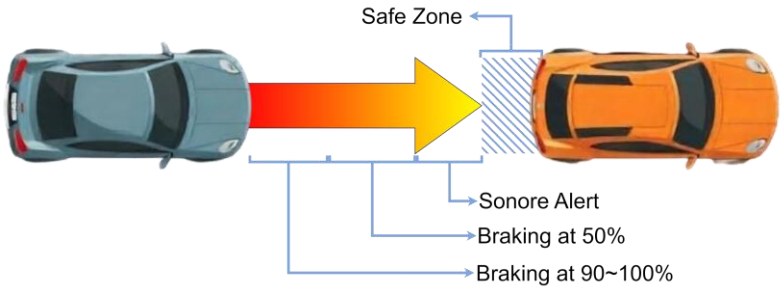


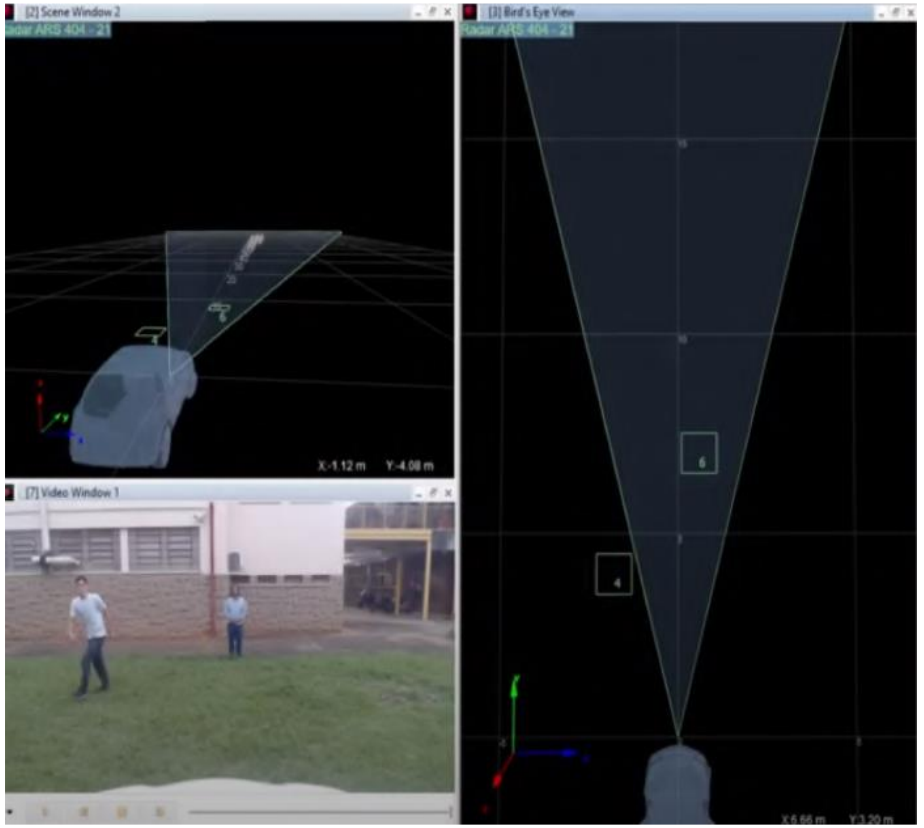
5.5. AI for Decision and Control

Automatic Emergency Braking (AEB)

- Tool: Automated Driving Toolbox™ + Deep Learning Toolbox™
- Use: Predict collision and apply braking





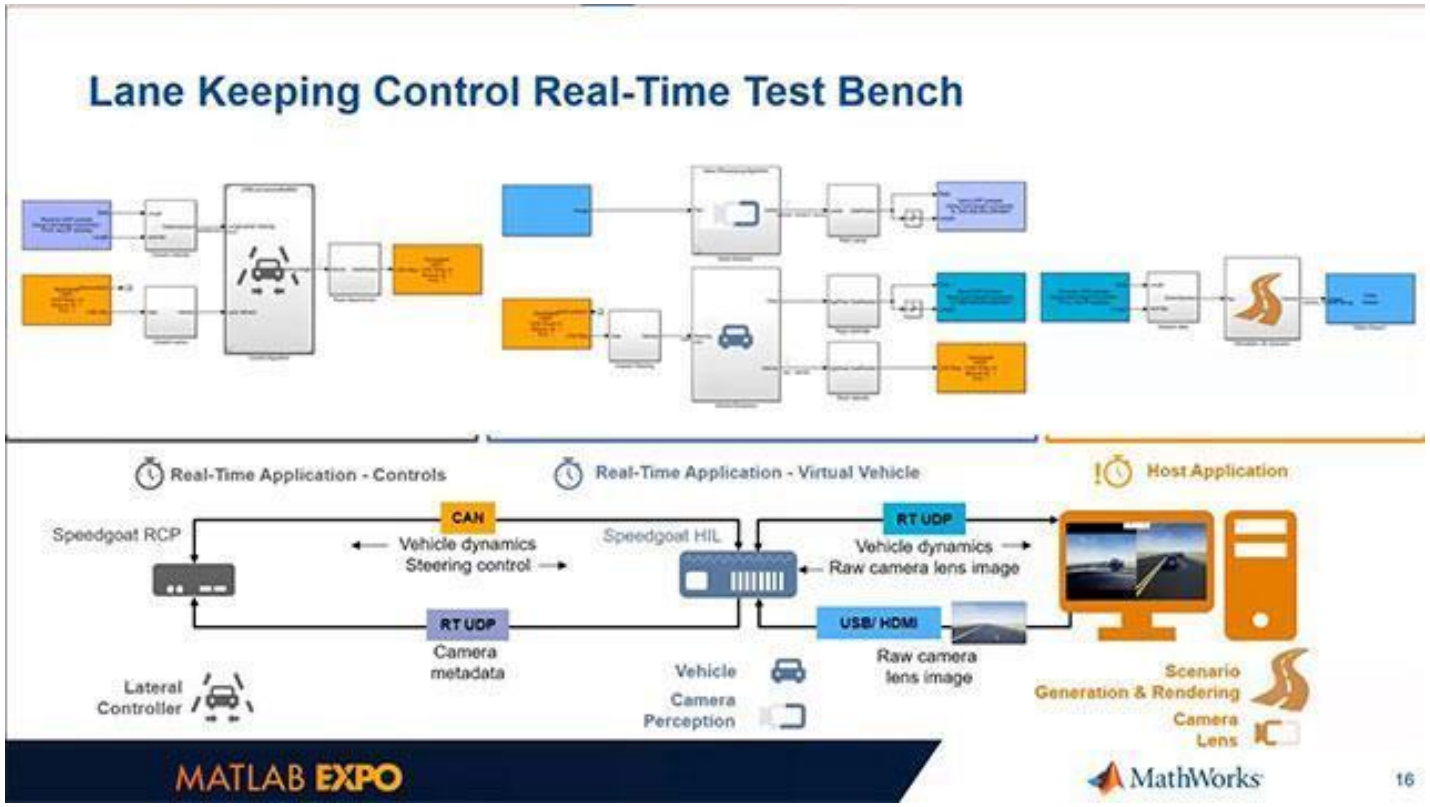


Source: Tiago Horiy and Lucas Portello

5.5. AI for Decision and Control

Lane Keeping Assist (LKA) via End-to-End Learning

- Tool: Deep Learning Toolbox™ + Simulink®
- Use: Steering control from raw camera input

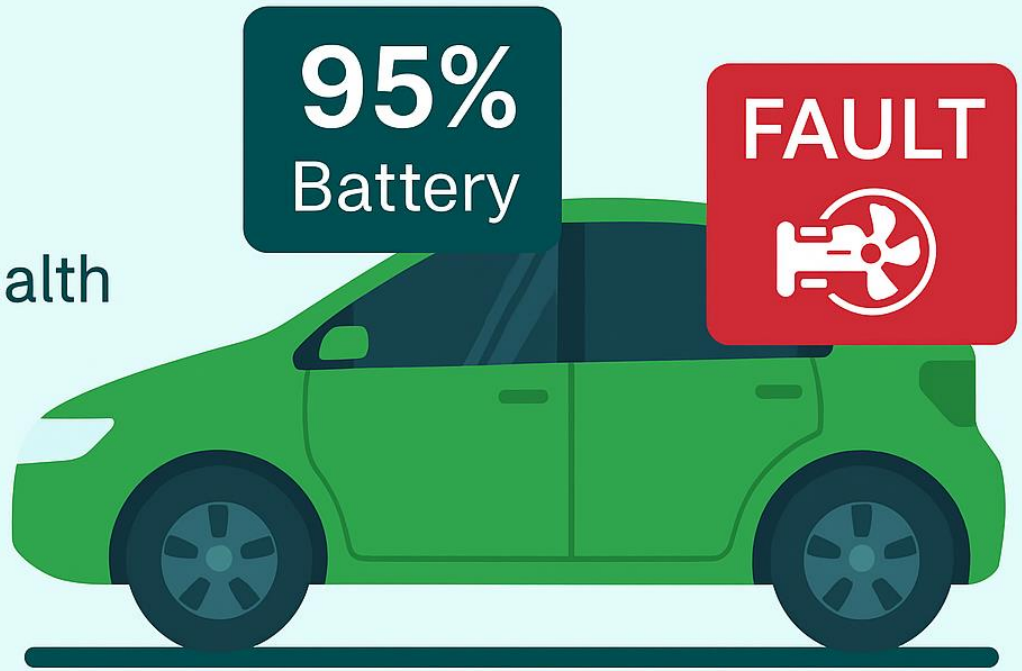


https://www.mathworks.com/videos/real-time-prototyping-and-testing-for-adas-lane-keeping-and-following-assist-systems-1603141419864.html

5.6. Predictive and Diagnostic AI

Predictive Maintenance for Electric Vehicles

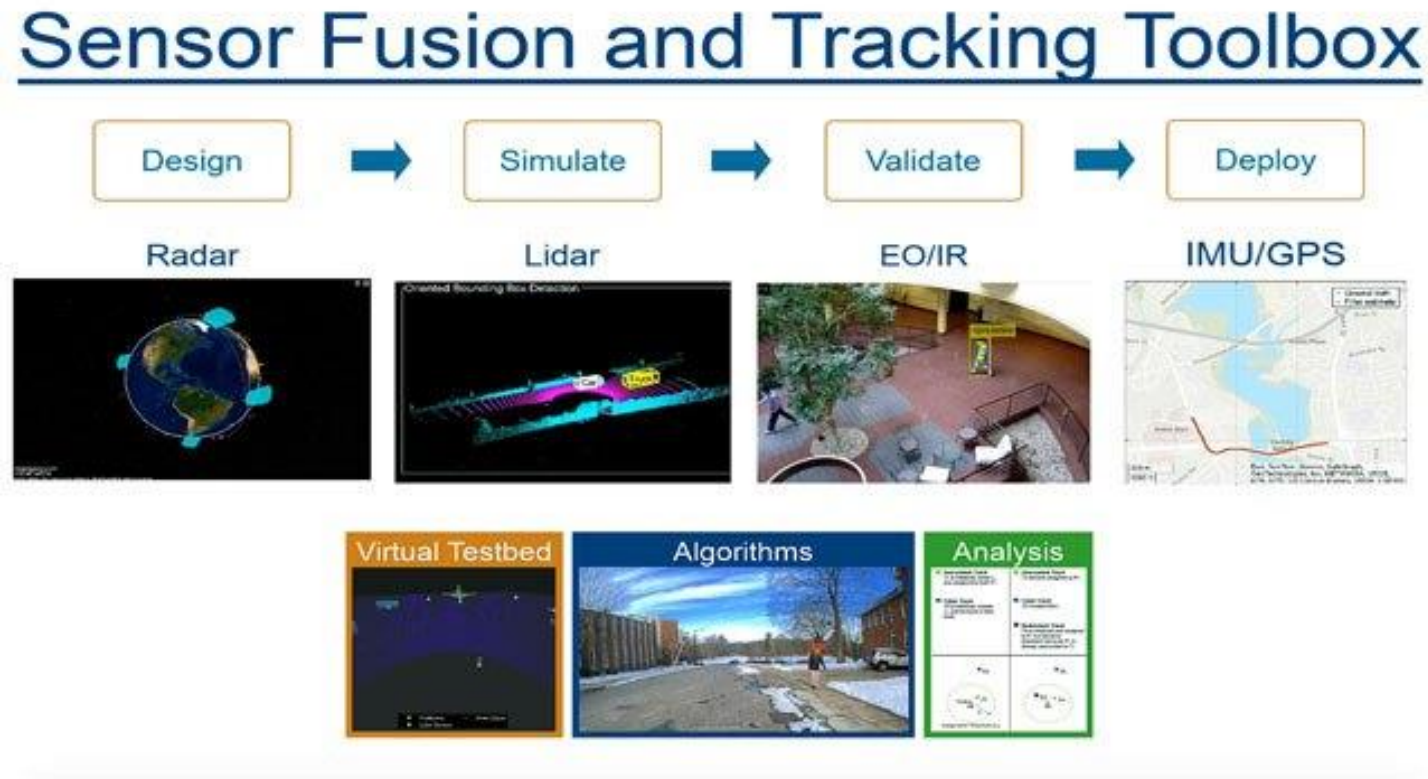
- Tool: Predictive Maintenance Toolbox™
- Use: Battery health estimation and motor fault prediction



5.6. Predictive and Diagnostic AI

AI for Radar and Sensor Fusion

- Tool: Sensor Fusion and Tracking Toolbox™
- Use: Combine radar, lidar, camera, and IMU data for robust perception

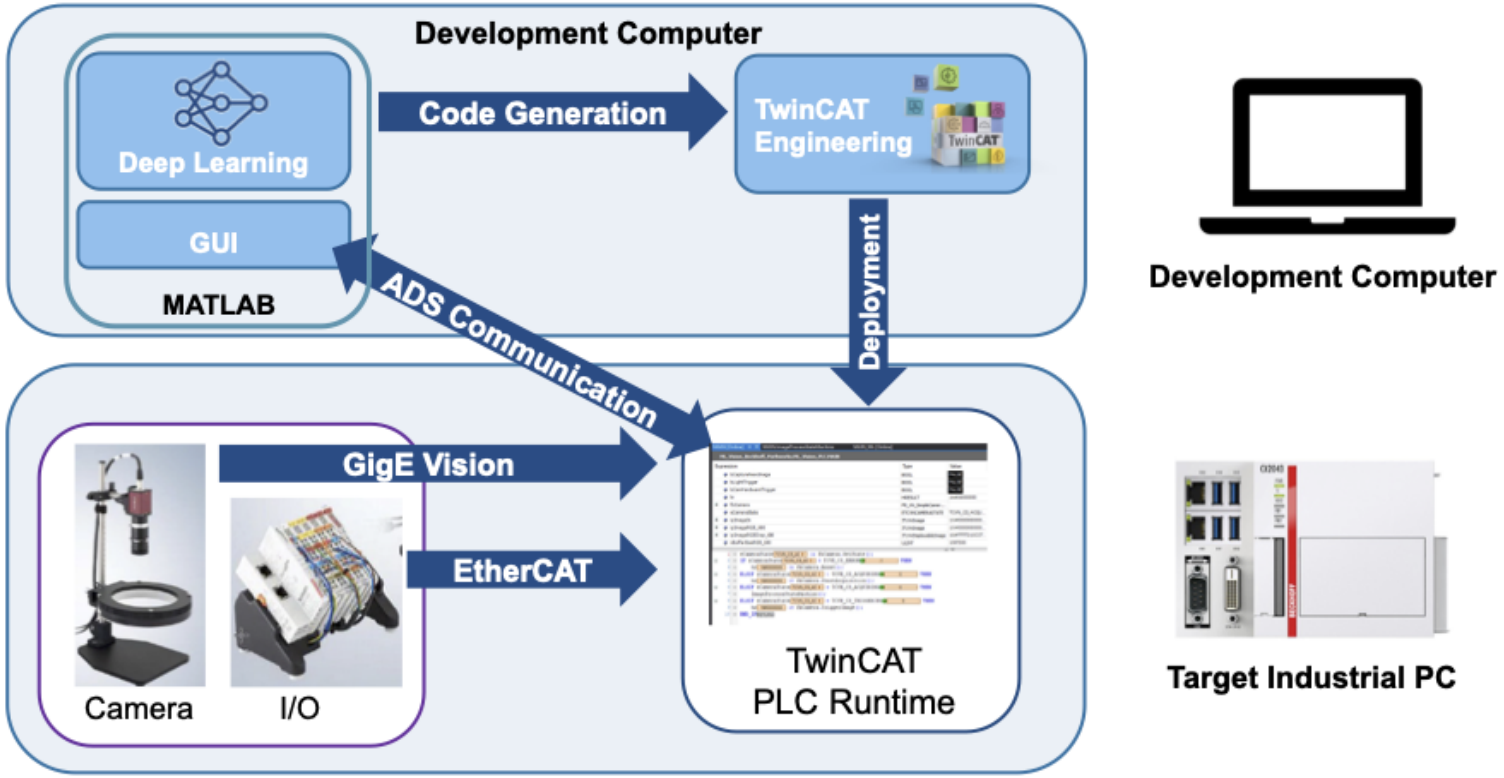


https://www.mathworks.com/videos/what-is-sensor-fusion-and-tracking-toolbox-1746697750531.html

5.7. AI in Manufacturing and Validation

AI-Based Quality Control in Production Lines

- Tool: Computer Vision Toolbox™ + Statistics and Machine Learning Toolbox™
- Use: Visual inspection and defect detection



5.7. AI in Manufacturing and Validation

Scenario Generation for ADAS Validation Using AI

- Tool: Automated Driving Toolbox™ + Reinforcement Learning Toolbox™
- Use: Generate test scenarios for simulation and HIL environments

6. Challenges and Future Directions

- Data quality and annotation challenges
- Real-time implementation and embedded deployment (GPU, FPGA)
- Explainable AI (XAI) and safety standards (ISO 26262, SOTIF, ISO 21434)
- Integration with **Vehicle-to-Everything (V2X)** and **cloud platforms**
- **Visual**: Future roadmap of AI in automotive

7. References

- MathWorks, Automated Driving Toolbox™
- DocumentationMathWorks, Reinforcement Learning Toolbox™
- User GuideMathWorks, Predictive Maintenance Toolbox™ Examples
- MathWorks, Deep Learning with MATLAB® (2024)
- IEEE Transactions on Intelligent Transportation SystemsSAE J3016 — Levels of Driving Automation
- ISO 26262 — Functional Safety for Road VehiclesSOTIF ISO/PAS 21448 — Safety of the Intended Functionality
- MathWorks Webinar — AI-Powered Design for Automotive Systems

THANK YOU!

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